

Network Systems  
Science & Advanced  
Computing  
Biocomplexity Institute  
& Initiative  
University of Virginia

# Analysis of COVID-19 in Virginia

July 7<sup>th</sup>, 2021

(data current to July 5<sup>th</sup> – June 7<sup>th</sup>)

Biocomplexity Institute Technical report: TR 2021-076



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**BIOCOMPLEXITY** INSTITUTE

[biocomplexity.virginia.edu](https://biocomplexity.virginia.edu)

# About Us

- Biocomplexity Institute at the University of Virginia
  - Using big data and simulations to understand massively interactive systems and solve societal problems
- Over 20 years of crafting and analyzing infectious disease models
  - Pandemic response for Influenza, Ebola, Zika, and others



## Points of Contact

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# Overview

- **Goal:** Understand impact of COVID-19 mitigations in Virginia
- **Approach:**
  - Calibrate explanatory mechanistic model to observed cases
  - Project based on scenarios for next 4 months
  - Consider a range of possible mitigation effects in "what-if" scenarios
- **Outcomes:**
  - Ill, Confirmed, Hospitalized, ICU, Ventilated, Death
  - Geographic spread over time, case counts, healthcare burdens

# Key Takeaways

Projecting future cases precisely is impossible and unnecessary.

Even without perfect projections, we can confidently draw conclusions:

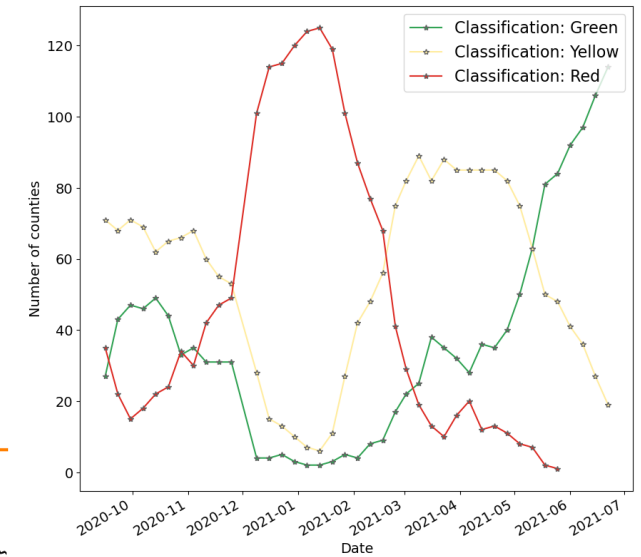
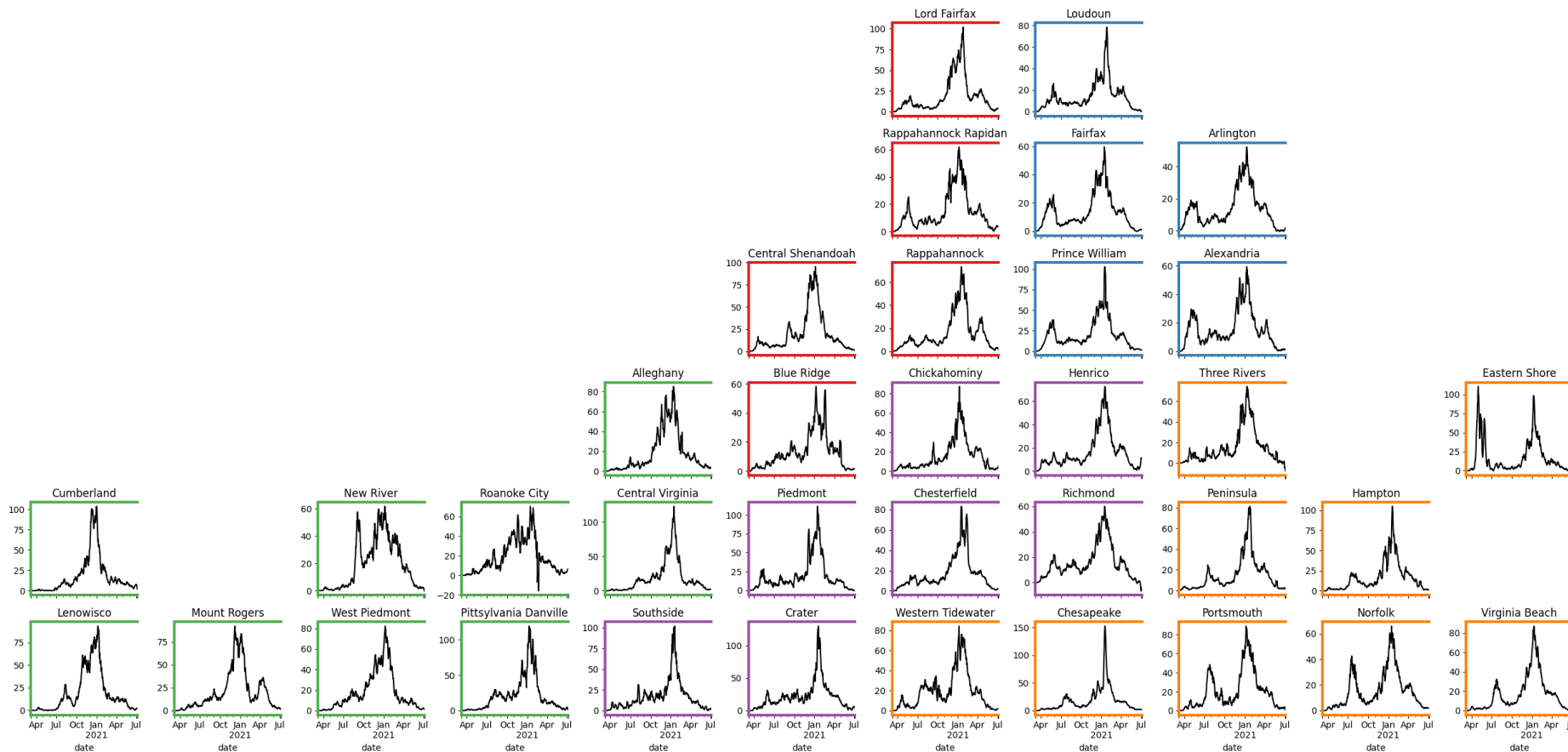
- **Case rates in Virginia have slightly risen, some districts with moderate growth**
- VA mean weekly incidence slightly up to 2.1/100K from 1.9/100K, US flat at 4.2/100K (from 3.9/100K)
- Vaccination rates continue to be slow while measured acceptance among unvaccinated remains steady
- Delta variant continues to grow, causing surges in other states and increased hospitalizations

The situation continues to change. Models continue to be updated regularly.

# Situation Assessment

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# Case Rates (per 100k) and Test Positivity



<https://data.cms.gov/stories/s/q5r5-gjyu>

## County level test positivity from RT-PCR tests.

**Green:** <5.0%  
(or with <20 tests in past 14 days)

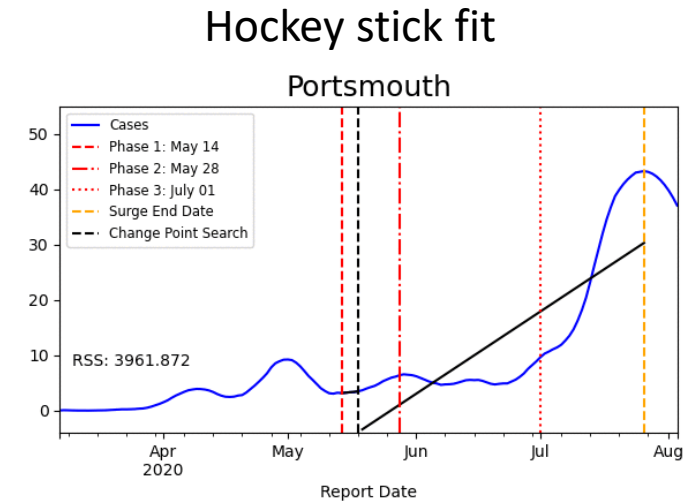
**Yellow:** 5.0%-10.0%  
(or with <500 tests and <2000 tests/100k and >10% positivity over 14 days)

**Red:** >10.0%  
(and not "Green" or "Yellow")

# District Trajectories

**Goal:** Define epochs of a Health District's COVID-19 incidence to characterize the current trajectory

**Method:** Find recent peak and use hockey stick fit to find inflection point afterwards, then use this period's slope to define the trajectory

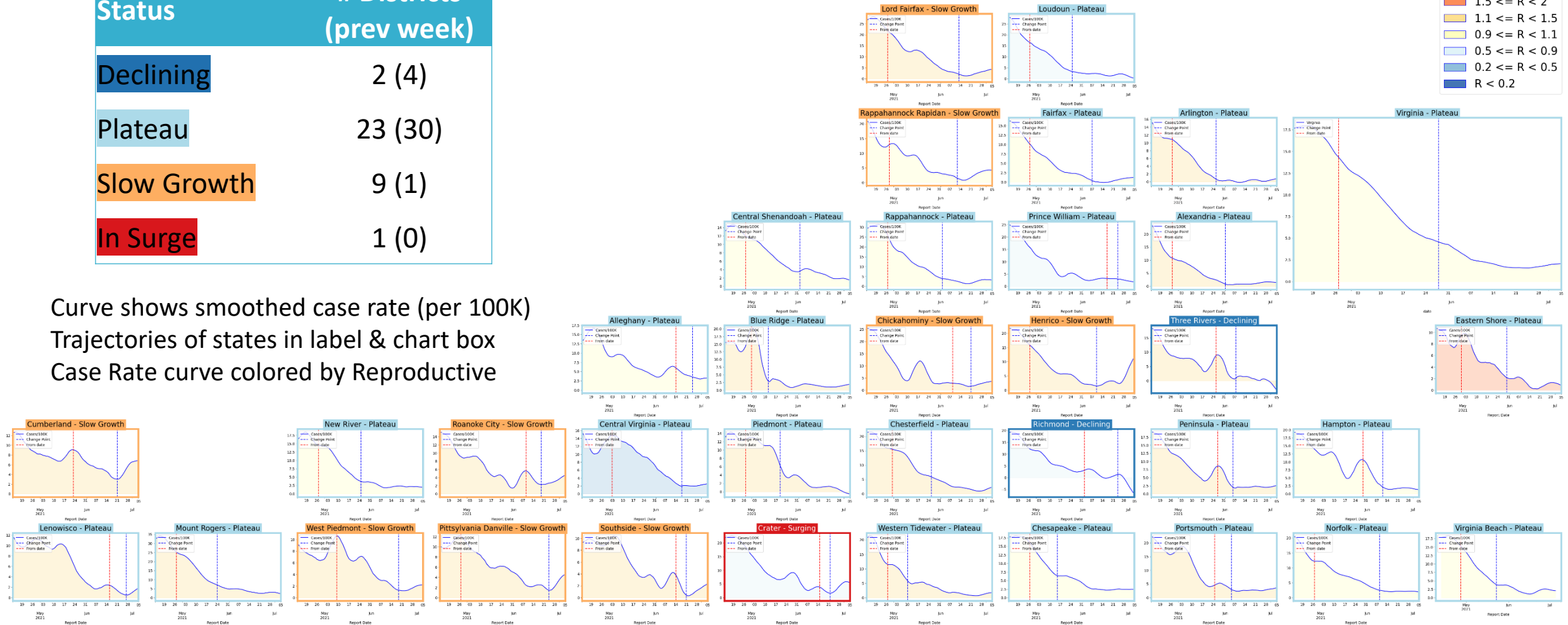


Trajectory	Description	Weekly Case Rate (per 100K) bounds	# Districts (prev week)
<b>Declining</b>	Sustained decreases following a recent peak	below -0.9	2 (4)
<b>Plateau</b>	Steady level with minimal trend up or down	above -0.9 and below 0.5	23 (30)
<b>Slow Growth</b>	Sustained growth not rapid enough to be considered a Surge	above 0.5 and below 2.5	9 (1)
<b>In Surge</b>	Currently experiencing sustained rapid and significant growth	2.5 or greater	1 (0)

# District Trajectories – last 10 weeks

Status	# Districts (prev week)
Declining	2 (4)
Plateau	23 (30)
Slow Growth	9 (1)
In Surge	1 (0)

Curve shows smoothed case rate (per 100K)  
Trajectories of states in label & chart box  
Case Rate curve colored by Reproductive





# Estimating Daily Reproductive Number

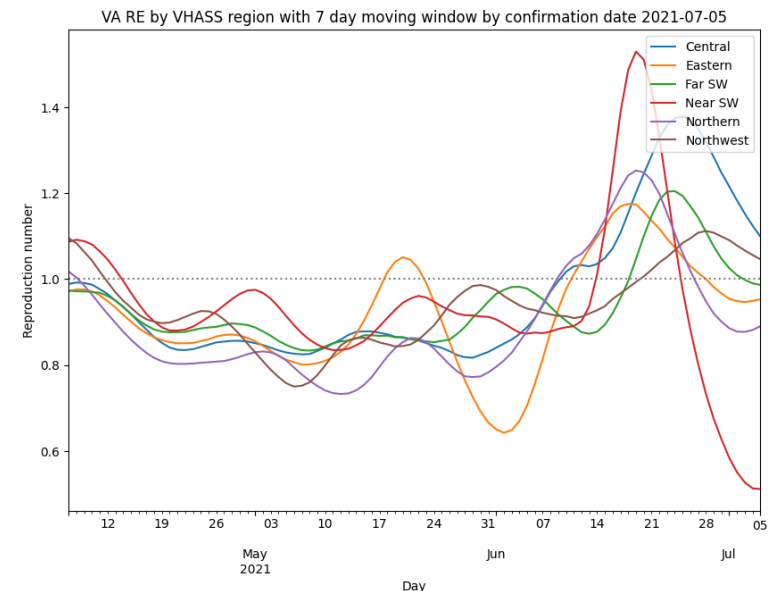
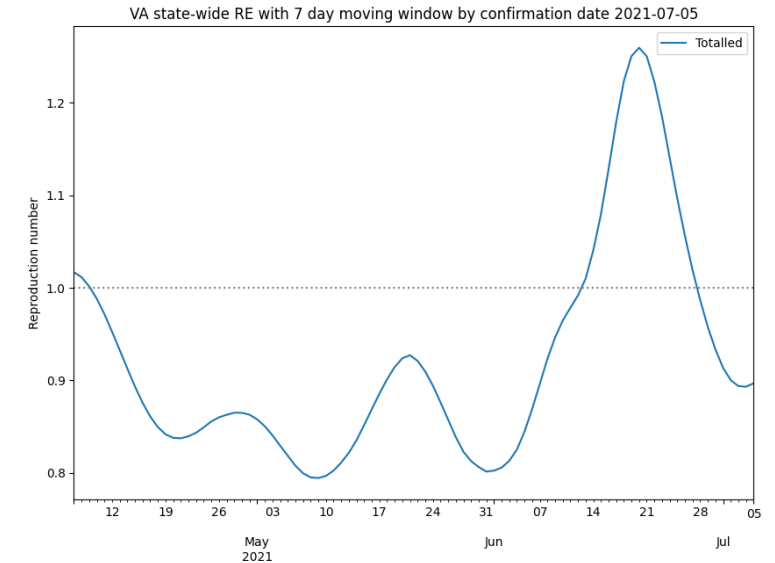
## July 6<sup>th</sup> Estimates

Region	Date Confirmed $R_e$	Date Confirmed Diff Last Week
State-wide	0.863	-0.258
Central	1.091	-0.089
Eastern	0.942	-0.076
Far SW	0.969	-0.147
Near SW	0.398	-0.812
Northern	0.814	-0.285
Northwest	1.003	0.031

### Methodology

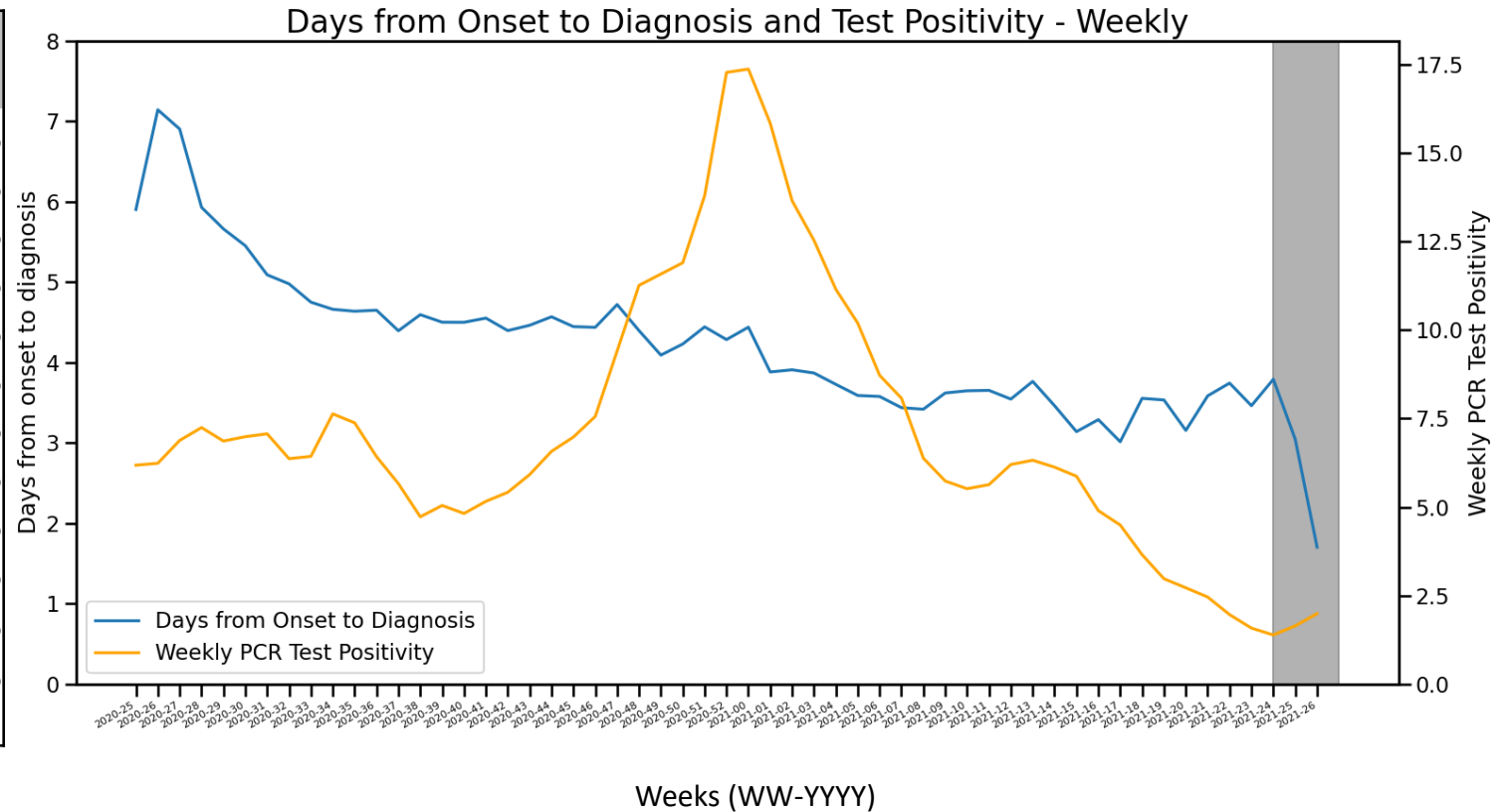
- Wallinga-Teunis method (EpiEstim<sup>1</sup>) for cases by confirmation date
- Serial interval: updated to discrete distribution from observations (mean=4.3, Flaxman et al, Nature 2020)
- Using Confirmation date since due to increasingly unstable estimates from onset date due to backfill

1. Anne Cori, Neil M. Ferguson, Christophe Fraser, Simon Cauchemez. A New Framework and Software to Estimate Time-Varying Reproduction Numbers During Epidemics. American Journal of Epidemiology, Volume 178, Issue 9, 1 November 2013, Pages 1505–1512, <https://doi.org/10.1093/aje/kwt133>

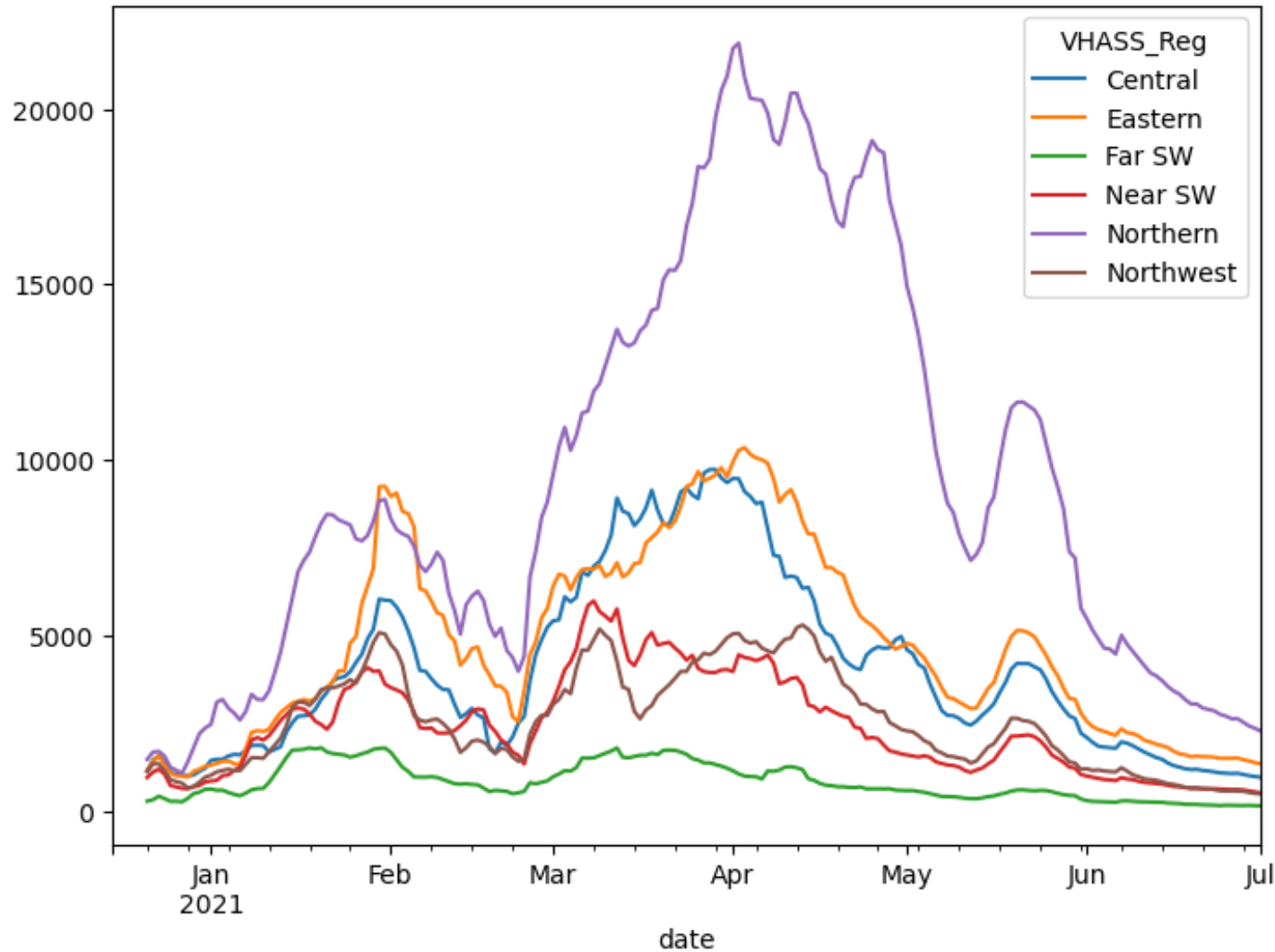


# Changes in Case Detection

Timeframe (weeks)	Mean days	% difference from overall mean
July (26-30)	6.22	8.89%
Aug (31-34)	4.87	-14.73%
Sept (35-38)	4.57	-20.00%
Oct (39-43)	4.48	-21.52%
Nov (44-47)	4.54	-20.46%
Dec (48-49)	4.29	-24.91%
Jan (00-04)	3.96	-30.58%
Feb (05-08)	3.5	-38.63%
Mar (09-13)	3.64	-36.17%
Apr (14-17)	3.22	-43.52%
May (18-21)	3.46	-39.48%
June (22-?)	3.66	-35.82%
Overall (13 - 19)	5.71	--

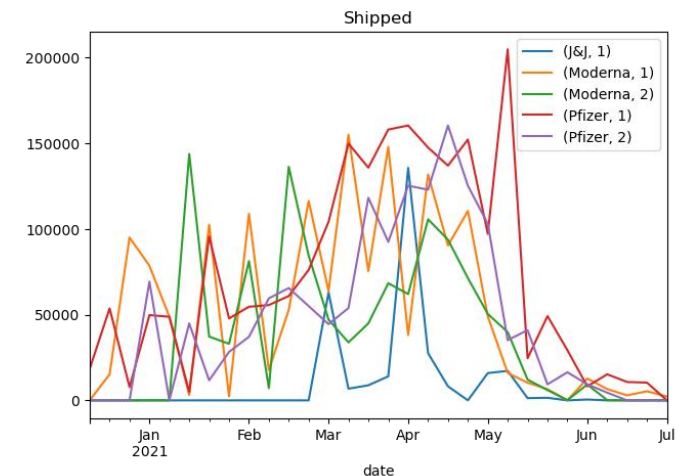


# Vaccination Administration Slows



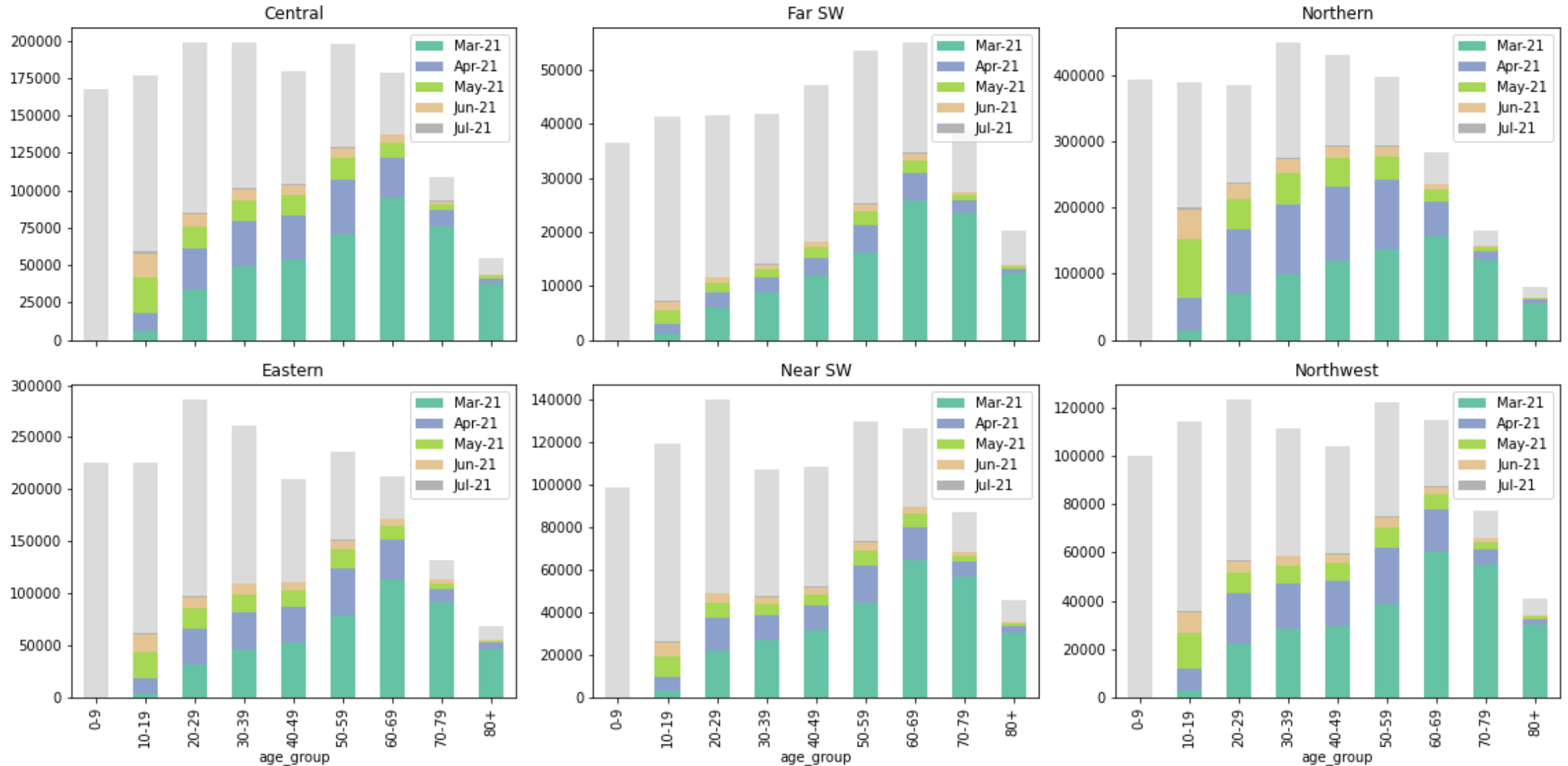
## Regional Vaccine courses initiated per day:

- Total counts of first dose of vaccines across regions
- Recent rise due to opening of vaccinations to 12-16 year olds



Shipments have slowed with decreased demand

# Vaccinations Shift to Younger Populations

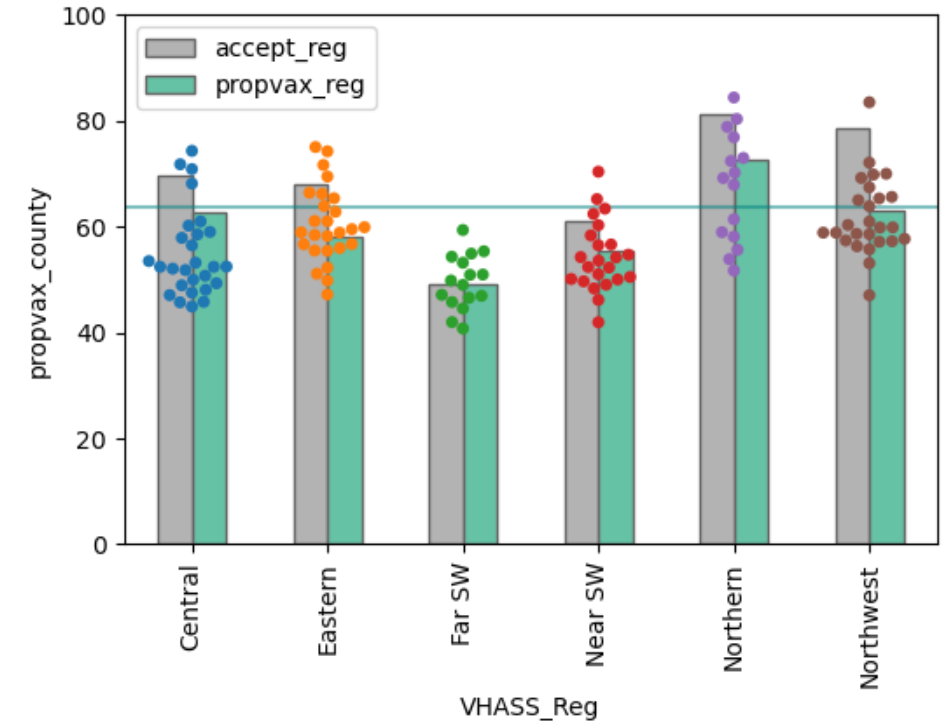


# Vaccination Acceptance by Region

## Corrections to surveys:

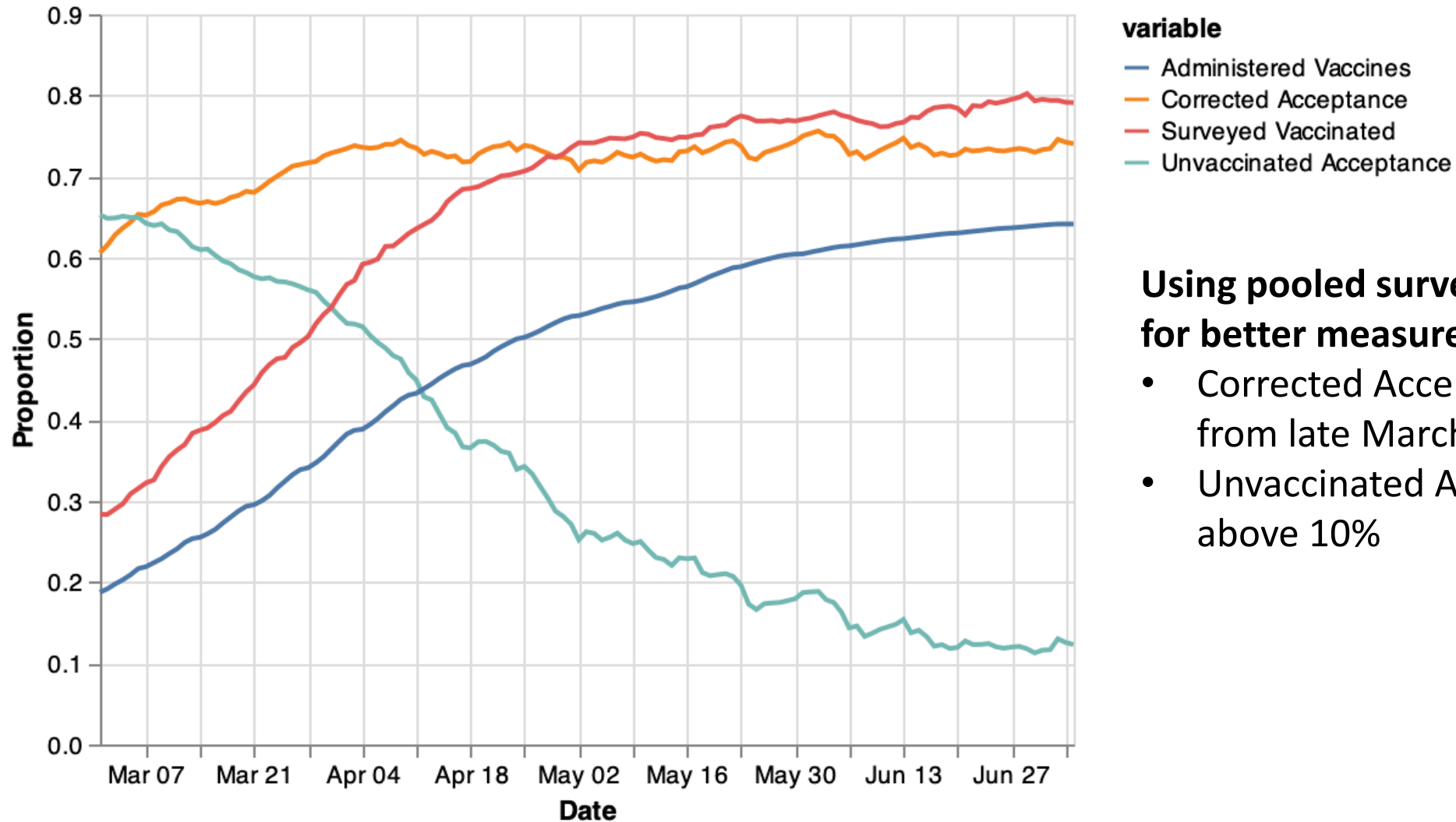
- Facebook administered survey is timely and broad, but biased by who accesses Facebook and answers the survey
- Correction approach:
  - Calculate an over-reporting fraction based on reported vaccinations compared to VDH administration data
  - Cross-validate coarse corrections against HPS survey at the state level and corrected in same manner

Region	COVIDcast accepting corrected	COVIDcast accepting corrected (last week)	VDH proportion vaccinated	COVIDcast reported vaccinated
Central	66%	68%	58%	82%
Eastern	62%	58%	52%	84%
Far SW	60%	53%	41%	66%
Near SW	61%	60%	51%	75%
Northern	78%	80%	67%	88%
Northwest	67%	67%	58%	79%



**Grey Bar:** Survey measured and corrected acceptance  
**Green Bar:** Proportion of eligible population administered a vaccine  
**Dots:** Proportion administered at least one dose for each county

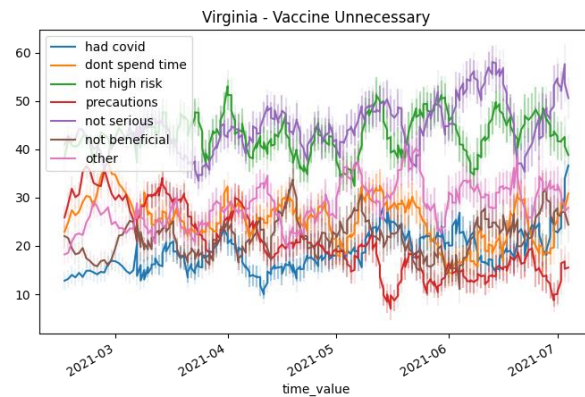
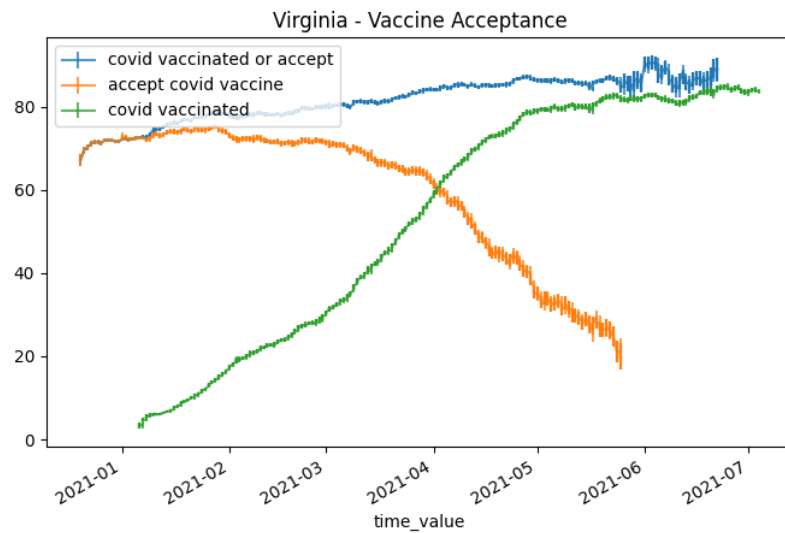
# Components of Vaccine Acceptance in VA



**Using pooled surveys (7 days) allows for better measurement over time**

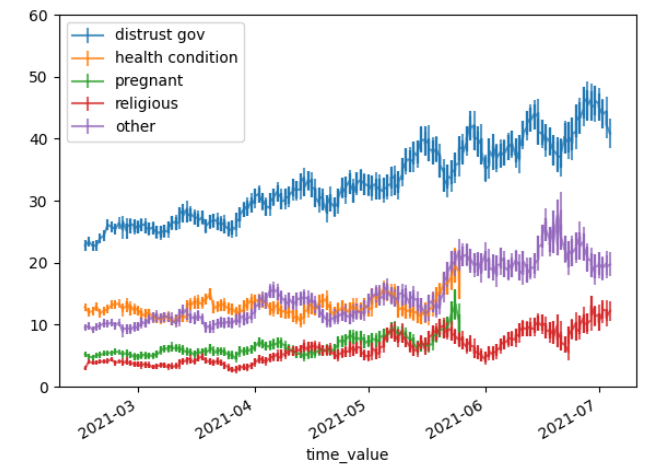
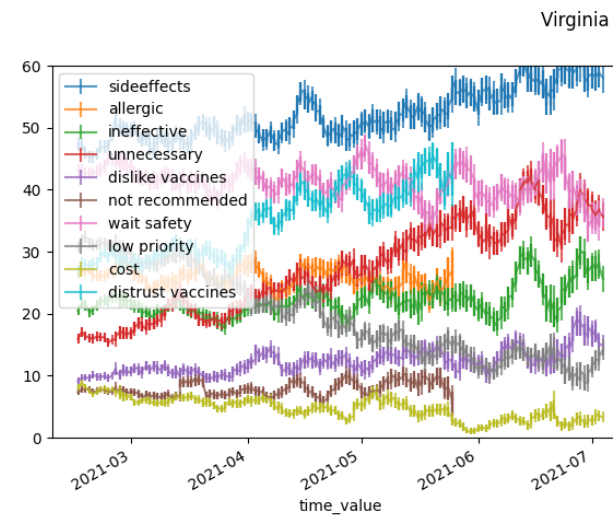
- Corrected Acceptance holds steady from late March in 7—75% range
- Unvaccinated Acceptance remains above 10%

# Vaccine Acceptance in Virginia - COVIDcast



## Acceptance remains high:

- Proportion of Virginians that have already or would definitely or probably accept vaccination if offered today
- *Survey respondents are reporting high levels of vaccination of ~80% reflecting bias of the mechanism*
- **Top reasons for hesitancy:** side effects, distrust (increasing), unnecessary (increasing)
- **More likely to take if recommended by:** doctors and friends
- **Reasons unnecessary:** Not serious, not high risk, or other



Data Source: <https://covidcast.cmu.edu>

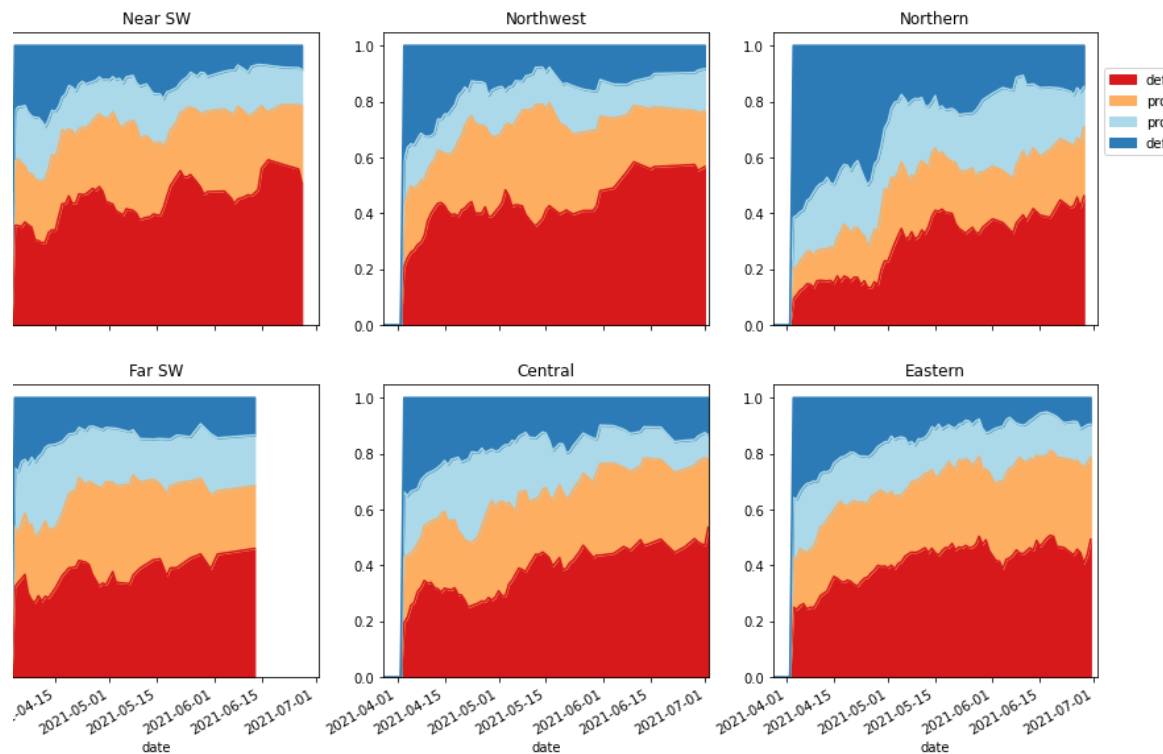


# Vaccine Acceptance by Region- COVIDcast

## Levels of Acceptance and potential acceptance in flux:

- Nearly all the “Definitely Yes” have been vaccinated, yet there are 5-10% remaining across the regions
- Northwest and Southwest (to lesser degree) see growth in “probably not”, seemingly from “definitely not”

### Unvaccinated Only



### All Respondents



Data Source: <https://covidcast.cmu.edu>

8-Jul-21

 UNIVERSITY of VIRGINIA

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# SARS-CoV2 Variants of Concern

**Emerging new variants will alter the future trajectories of pandemic and have implications for future control**

- Emerging variants can:
  - Increase transmissibility
  - Increase severity (more hospitalizations and/or deaths)
  - Limit immunity provided by prior infection and vaccinations
- Genomic surveillance remains very limited
  - Challenges ability to estimate impact in US to date and estimation of arrival and potential impact in future

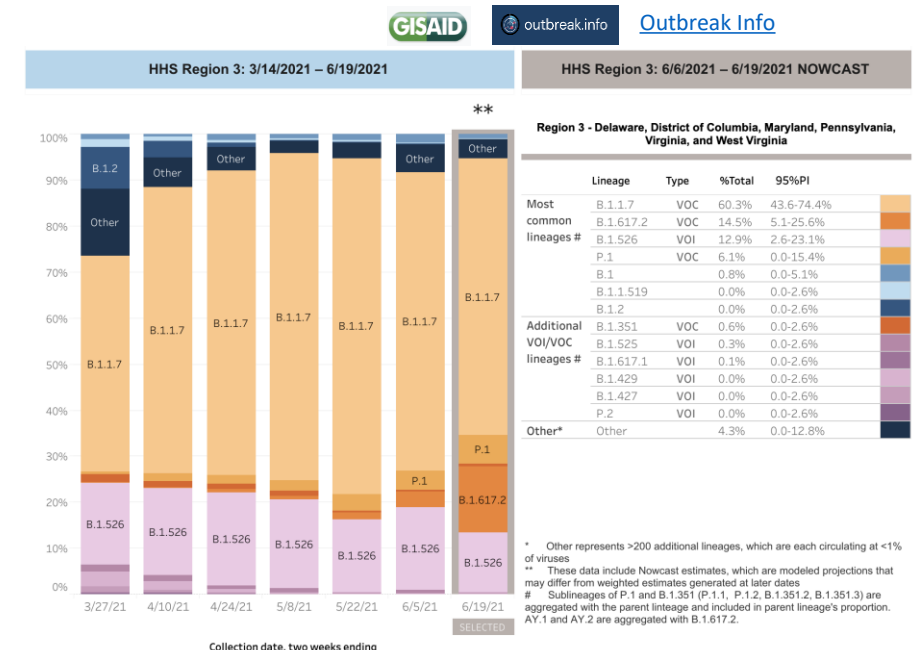
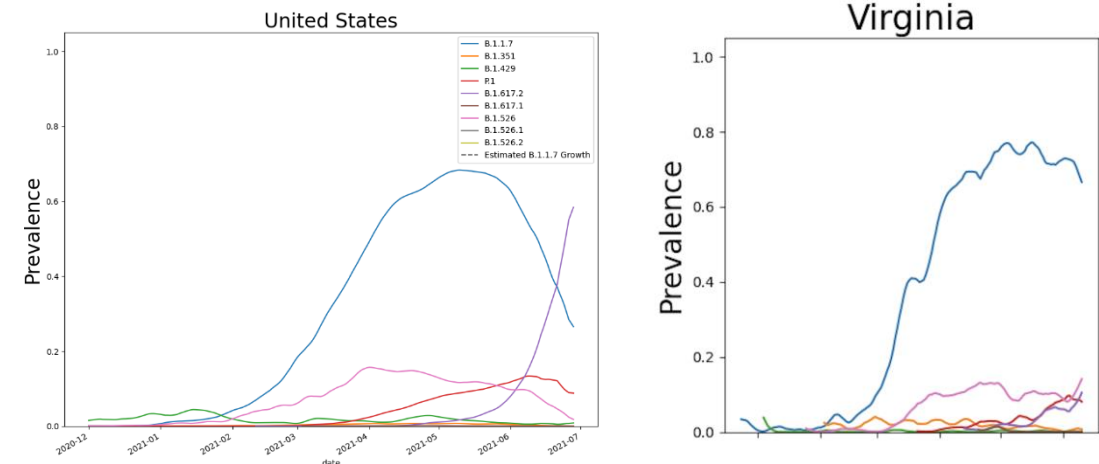
	New WHO Name	Transmissibility	Immune Evasiveness	Vaccine Effectiveness <sup>^</sup>
Ancestral		—	—	✓
D614G		+	—	✓
B.1.1.7	Alpha	+++	—	✓
B.1.351	Beta	+	++++	✓
P.1	Gamma	++	++	✓
B.1.429	Epsilon	+	+	✓
B.1.526	Iota	+	+	✓
B.1.617.2	Delta	++++*	++ <sup>#</sup>	✓

<sup>^</sup>Relative transmissibility to B.1.1.7 yet to be fully defined

<sup>\*</sup>Effectiveness from real world evidence vs. severe illness, not all vaccines are effective vs all variants, and importance of 2-doses, especially for B.1.617.2 for which 1 dose of mRNA or AZ is only ~30% effective <sup>#</sup> May carry more immune escape than P.1, to be determined



WHO and Eric Topol



\* Other represents >200 additional lineages, which are each circulating at <1% of viruses  
<sup>\*\*</sup> These data include Nowcast estimates, which are modeled projections that may differ from weighted estimates generated at later dates  
<sup>#</sup> Sublineages of P.1 and B.1.351 (P.1.1, P.1.2, B.1.351.2, B.1.351.3) are aggregated with the parent lineage and included in parent lineage's proportion. AY.1 and AY.2 are aggregated with B.1.617.2.



CDC Variant Tracking

# SARS-CoV2 Variants of Concern

## Alpha $\alpha$ - Lineage B.1.1.7

**Prevalence:** Levels have stalled and are now dropping in most states; flat in VA

**Transmissibility:** Estimated increase of 50% compared to previous variants. B.1.1.7's mutations boost its overall levels of viremia; [study from Public Health England](#) shows contacts of B.1.1.7 cases are more likely (50%) to test positive

**Severity:** Increased risk of hospitalization (60%) and mortality (60%). [Danish](#) study shows B.1.1.7 to have a 64% higher risk of hospitalization, while [Public Health Scotland](#) studies showed a range of 40% to 60%; [Study in Nature](#) estimates 60% higher mortality

## Beta $\beta$ - Lineage B.1.351

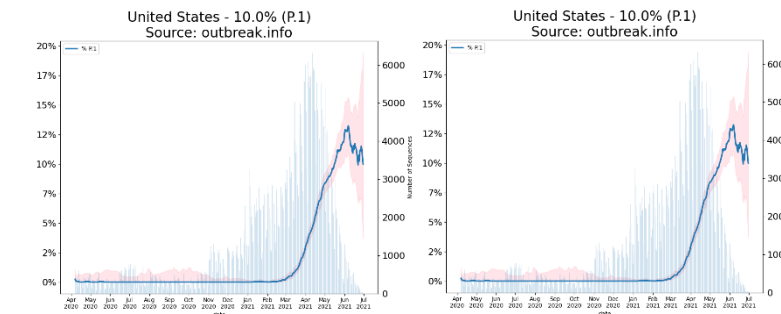
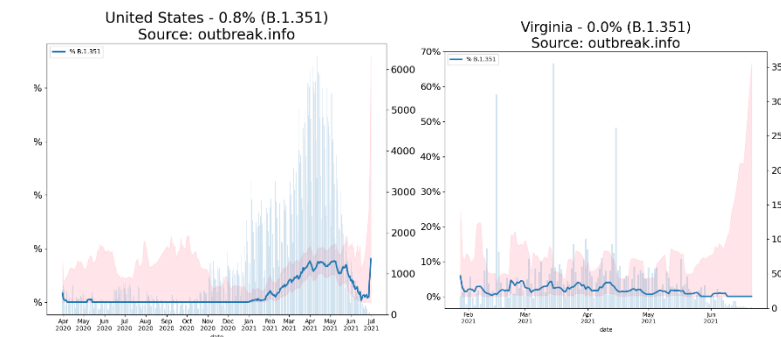
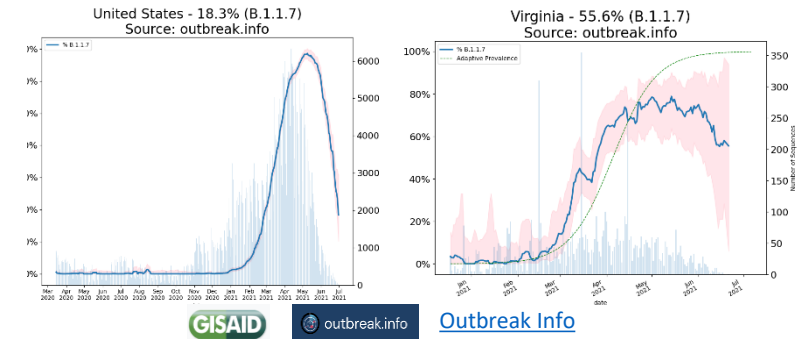
**Prevalence:** Levels have remained low, as this variant's transmissibility can't compete with B.1.1.7, however, as more of the population becomes immune it may gain an advantage

**Immune Escape:** Many studies show that convalescent sera from previously infected individuals does not neutralize B.1.351 virus well which is [predictive](#) of [protection](#), however, [vaccine induced immunity](#) shows [signs](#) of [effectiveness](#)

## Gamma $\gamma$ - Lineage P.1

**Prevalence:** Nationally at 10%, slow increase in VA at 9%

[Study](#) estimates 17-32% of all infections in Manaus in 2021 were reinfections, which helps explain [data from Brazil](#) demonstrating P.1's continued dominance in Rio despite presence of B.1.1.7



# SARS-CoV2 Variants of Concern

## Delta $\delta$ - Lineage B.1.617.2 and related subvariants

- Delta plus  $\delta+$  lineage which contains the K417N mutation is emerging as a sub-variant that is even more transmissible. Declared a VoC in India
- Strain shows [continued growth in Europe](#) and across US, predicted to predominate in coming weeks (July 2<sup>nd</sup> in VA), Scotland now experiencing highest daily case counts, driven by delta.
- [Several studies](#) estimate B.1.617.2 to have 100% faster growth than B.1.1.7, and a UK study suggests a 13% advantage over B.1.1.7; we are roughly tracking what seems to be a ~60% growth rate advantage in VA
- [More studies](#) show limited [immune escape](#) similar to B.1.351, however, many studies still suggest protection remains for vaccinated, especially 2 doses and mRNA vaccines
- [PHE study](#) shows limited efficacy of Astra-Zeneca with only one dose, efficacy returns following 2<sup>nd</sup> dose, [also stronger with a followup Pfizer](#)
- [Public Health Scotland study in Lancet](#) suggests Delta is 2x more likely to cause hospitalization than Alpha
- [New study](#) shows evasion of natural and of Pfizer vax (though weak) also shows transmissibility boost comes from more efficient fusion and lung cell entry

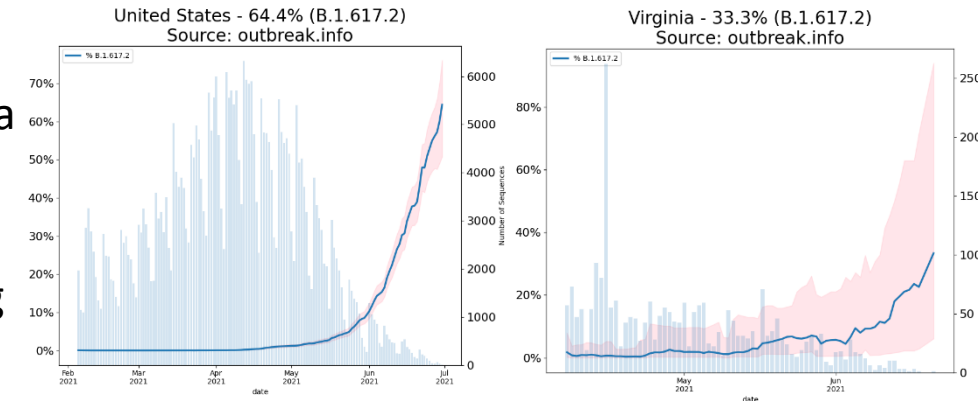
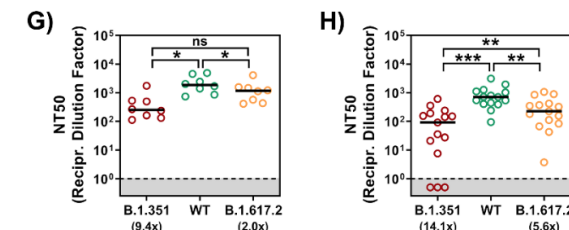


Table 1: Estimated vaccine effectiveness against hospitalisation

Vaccination status	Alpha			Delta		
	OR vs symptomatic disease	HR vs hospitalisation	VE vs hospitalisation	OR vs symptomatic disease	HR vs hospitalisation	VE vs hospitalisation
Any vaccine						
Dose 1	0.51 (0.48-0.55)	0.44 (0.28-0.70)	78% (65-86)	0.69 (0.64-0.75)	0.37 (0.22-0.63)	75% (57-85)
Dose 2	0.13 (0.1-0.15)	0.64 (0.24-1.72)	92% (78-97)	0.20 (0.18-0.23)	0.29 (0.11-0.72)	94% (85-98)
Pfizer						
Dose 1	0.53 (0.47-0.58)	0.32 (0.14-0.73)	83% (62-93)	0.64 (0.54-0.77)	0.10 (0.01-0.76)	94% (46-99)
Dose 2	0.06 (0.05-0.08)	0.88 (0.21-3.77)	95% (78-99)	0.12 (0.1-0.15)	0.34 (0.10-1.18)	96% (86-99)
Astrazeneca						
Dose 1	0.51 (0.48-0.55)	0.48 (0.30-0.77)	76% (61-85)	0.70 (0.65-0.76)	0.41 (0.24-0.70)	71% (51-83)
Dose 2	0.26 (0.21-0.32)	0.53 (0.15-1.80)	86% (53-96)	0.33 (0.28-0.39)	0.25 (0.08-0.78)	92% (75-97)

Public Health England study shows vaccines are effective against hospitalization with Delta variant infections (94-96% for Pfizer). Also shows that one dose AZ has much lower efficacy (71%) [PHE](#)



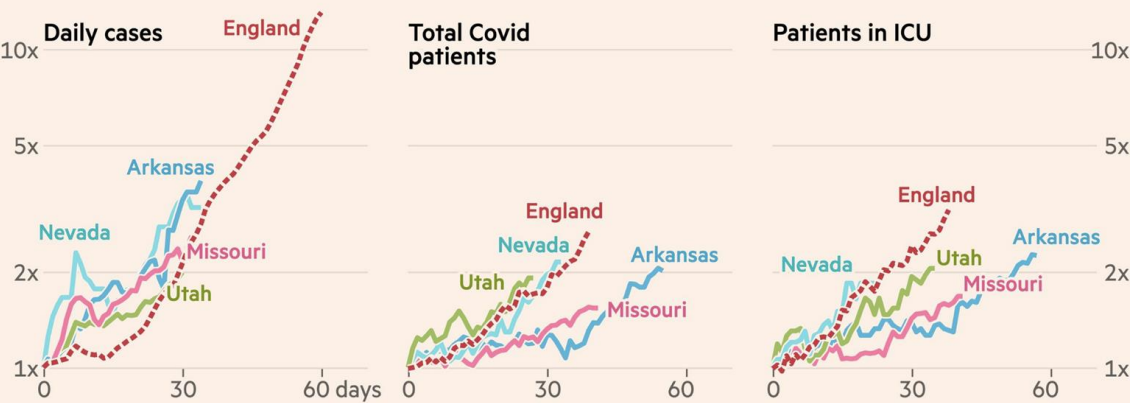
We show, that B.1.617.2 evades control by antibodies induced upon infection and even Pfizer's vaccine, although with lower efficiency as compared to B.1.351, as well as a common monoclonal treatment. Finally, we show increased Calu-3 lung cell entry and enhanced cell-to-cell fusion of B.1.617.2, which may contribute to augmented transmissibility and pathogenicity of this variant.

[BioRxiv](#)

# July 07, 2021 Strain/Vaccine update

Cases and hospitalisations are following broadly similar paths in the US and the UK so far

Relative increase in each metric (log scale), by number of days since it began to rise



Source: FT analysis of data from UK government Covid-19 dashboard and US CDC © FT

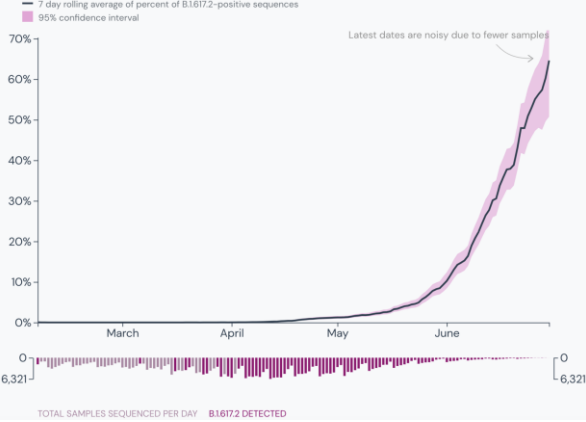
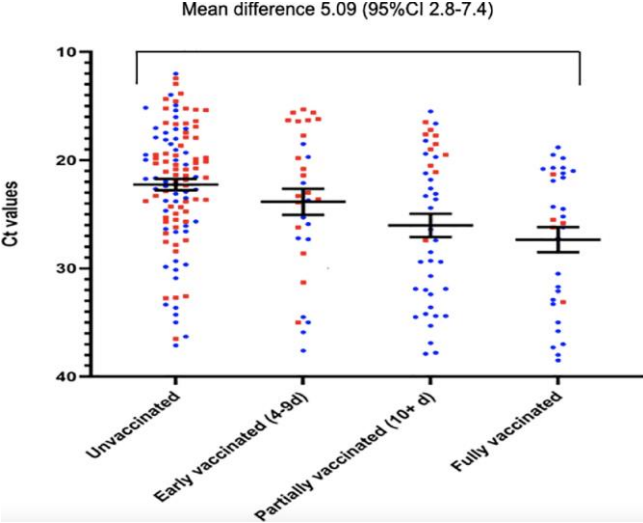
<https://twitter.com/jburnmurdoch/status/1412762156848799744>

**Table 3.** Viral RNA Load, Duration of Viral RNA Detection, Frequency of Febrile Symptoms, and Duration of Illness in Vaccinated and Unvaccinated Participants with SARS-CoV-2 Infection.\*

Variable	Unvaccinated	Partially or Fully Vaccinated	Difference (95% CI)
Viral RNA load			
No. assessed	155	16	—
Mean — log <sub>10</sub> copies/ml†	3.8±1.7	2.3±1.7	40.2 (16.3–57.3)‡
Duration of viral RNA detection			
No. assessed	155	16	—
Mean — days	8.9±10.2	2.7±3.0	6.2 (4.0–8.4)
Detection of viral RNA for >1 week — no./total no. (%)	113/156 (72.4)	4/16 (25.0)	0.34 (0.15–0.81)§
Febrile symptoms — no./total no. (%)¶	94/149 (63.1)	4/16 (25.0)	0.42 (0.18–0.98)
Total days of symptoms			
No. assessed	148	16	—
Mean — days	16.7±15.7	10.3±10.3	6.4 (0.4–12.3)
Days spent sick in bed			
No. assessed	147	15	—
Mean — days	3.8±5.9	1.5±2.1	2.3 (0.8–3.7)

CDC study shows mRNA vaccination suppression of covid infections as assessed with frequent NP swabs in nearly 4,000 participants 91% efficacy of blocking transmission of infection (2 doses); 40% reduction of viral load

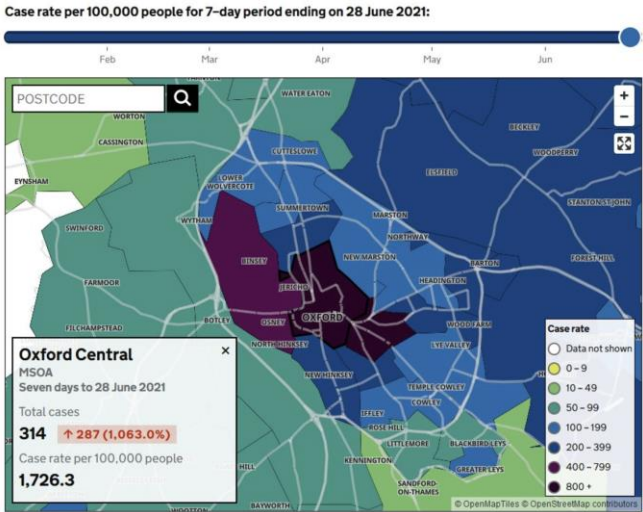
[https://www.nejm.org/doi/full/10.1056/NEJMoa2107058?query=featured\\_home](https://www.nejm.org/doi/full/10.1056/NEJMoa2107058?query=featured_home)



<https://outbreak.info/situation-reports?pango=B.1.617.2&loc=IND&loc=GBR&loc=USA&selected=USA>

These results suggest that BNT162b2 is moderately to highly effective in reducing infectivity, via preventing infection and through reducing viral shedding. Incidence of (v) symptomatic and (vi) symptomatic-infectious cases was significantly lower among fully vaccinated vs. unvaccinated individuals (VE(v)= 89.7%, 95%CI 84–94%, VE(vi)=88.1%, 95%CI 80–95%). The mean Ct-value was significantly higher in vaccinated vs. unvaccinated (27.3±1.2 vs. 22.2±1.0, p<0.001) and the proportion of positive SARS-CoV-2 antigen tests was also significantly lower among vaccinated vs. unvaccinated PCR-positive HCW (80% vs. 31%, p<0.001). Lower infectivity was correlated with higher IgG concentrations (R=0.36, p=0.01)

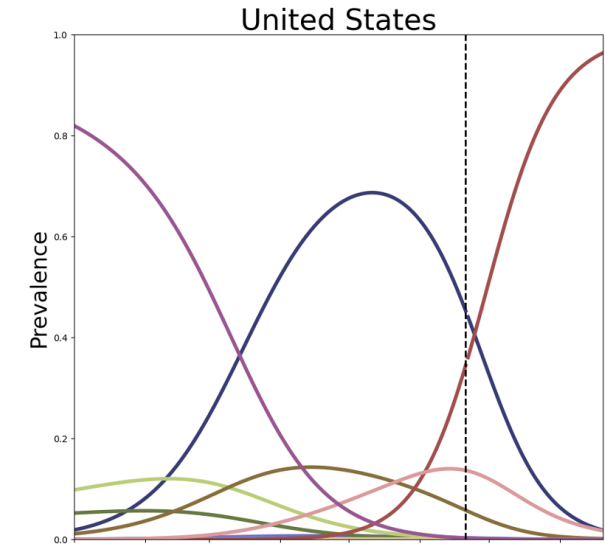
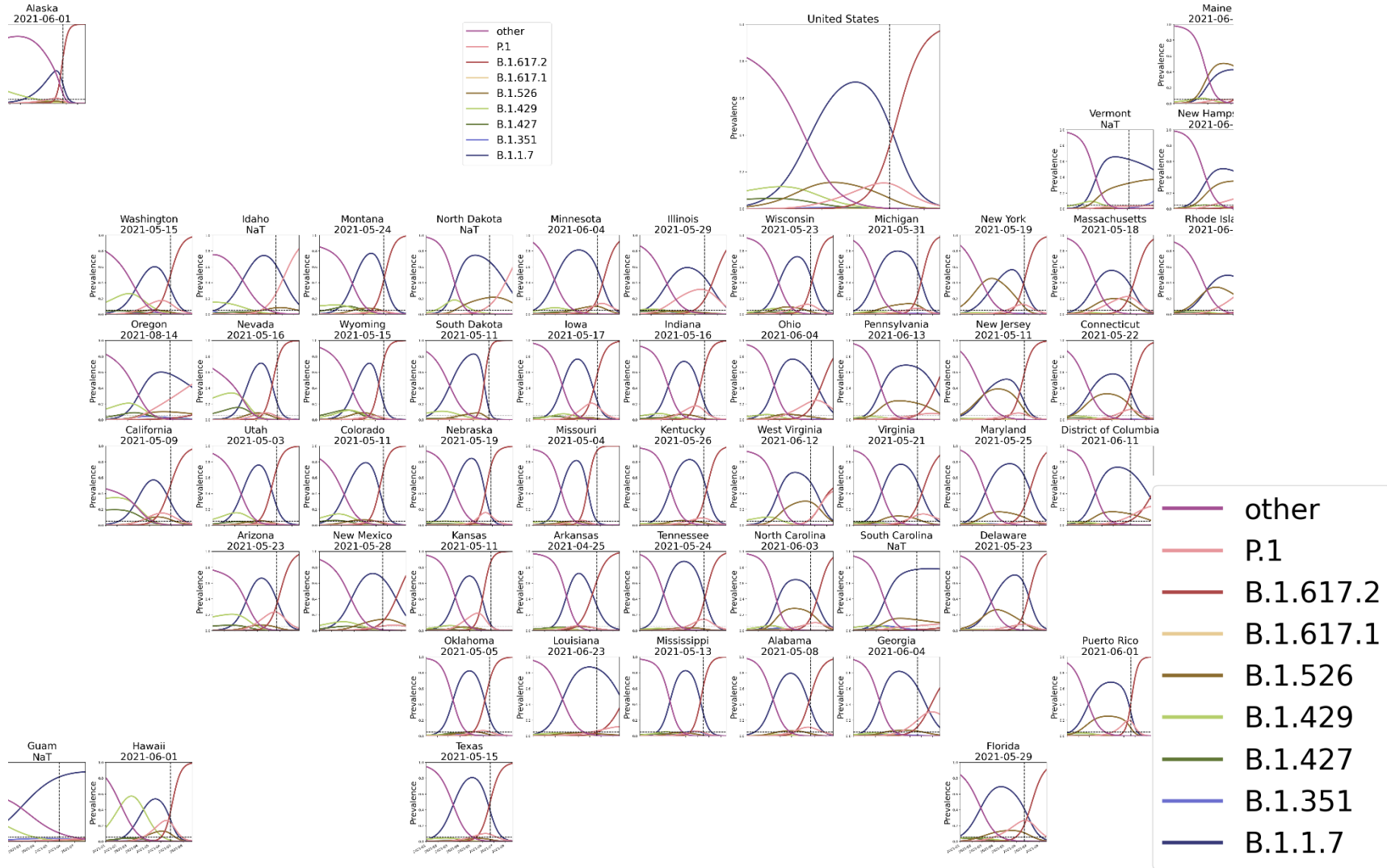
<https://www.sciencedirect.com/science/article/pii/S2666776221001277#fig0003>



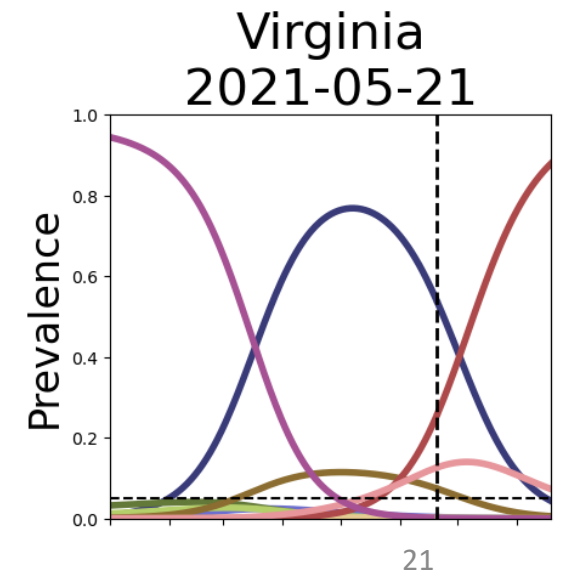
Cases up in Oxford by 1000% in past 7 days  
<https://coronavirus.data.gov.uk/>  
[https://twitter.com/Dr\\_D\\_Robertson/status/1411391546969231362](https://twitter.com/Dr_D_Robertson/status/1411391546969231362)



# Variant of Concern Trajectories

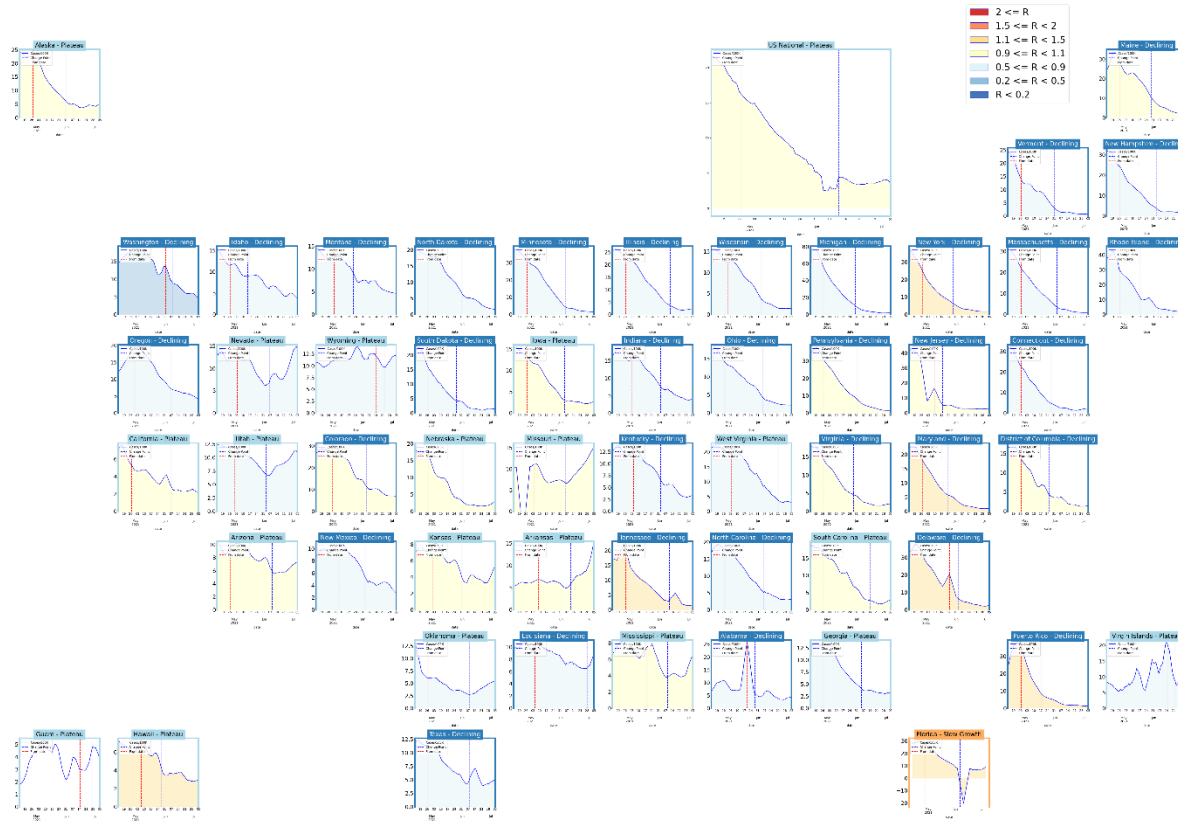


5% - May 21; 50% - July 2nd



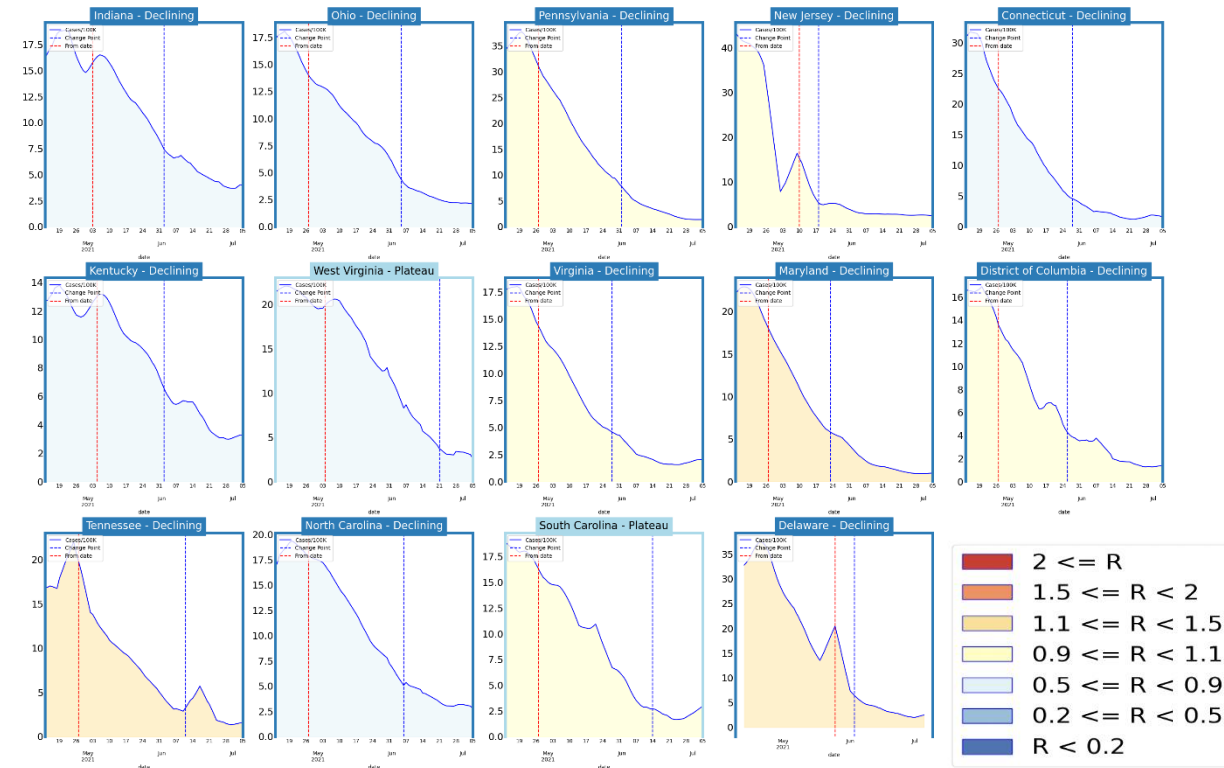
# Other State Comparisons

## Trajectories of States



- Nearly all states are declining
- Growth out west has slowed, recent reporting artifacts in some states perturb the otherwise calm picture

## Virginia and her neighbors



- VA and neighbors are all declining with steady pace
- Most neighbors are now below 10/100K level

# Key Takeaways

Projecting future cases precisely is impossible and unnecessary.

Even without perfect projections, we can confidently draw conclusions:

- **Case rates in Virginia have slightly risen, some districts with moderate growth**
- VA mean weekly incidence slightly up to 2.1/100K from 1.9/100K, US flat at 4.2/100K (from 3.9/100K)
- Vaccination rates continue to be slow while measured acceptance among unvaccinated remains steady
- Delta variant continues to grow, causing surges in other states and increased hospitalizations

The situation continues to change. Models continue to be updated regularly.

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# Questions?

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